C O S T A N A L Y S I S

A METHOD FOR OBTAINING COSTS OF CONSTRUCTION WORK AND COMPILATION OF THE DATA FOR ESTIMATING.

A THESIS

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Master of Science

degree.

by

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The public utility operates much the same as any other organization, yet its field is limited to the production, distribution and sale of its commodity under widely varying conditions of market and labor, and it cannot fix the price which it is to receive for the commodity.

To meet certain variable factors pertaining to the growth of any organization that is intimately connected with varying markets of labor and materials, it is necessary that each such organization maintain an Estimating department or its equivalent. The duties of such a department are to be equipped at all times to make a survey of the proposed work, analyze it with respect to existing laws, standards, modes of construction, method of handling, etc., and in order that the department function properly it must deal directly with the consumer for the producer.

Perhaps each organization has on file some information from which estimates can be made. If so, it has taken considerable time to prepare such data, and then too, such information might apply to a particular location.

A detailed cost analysis of work undertaken by an operating company can be easily obtained from field notes. This data could be put in such shape and units as to make the variable factor dealing with costs of small importance.

The following analysis of a job carried out in the state of Ohio will be taken as an example of a problem with which the estimating department comes in contact.

METHOD OF OBTAINING THESE DATA.

The labor cost was accounted for by taking hourly readings. These readings gave the number of men on each class of work on a particular section, their rate and the kind of work being done at the time the reading was taken.

The superintendence was obtained as follows: the total time of the superintendent, foremen, watchmen, toolmen, waterboys, and timekeepers was obtained for the day and this time was proportionately divided among the various classes of work done that day.

Team time was obtained in the same manner as the labor.

The material check was obtained by measuring the finished work and computing the cubical contents, from which the amount of each material was obtained. The actual weight of sand and stone used on the job was obtained by actually weighing each and computing the weight per unit volume; this being known the total weight used was calculated from the cubical contents of the finished work.

The results of these tests gave the following values: Sand as used 1.72 tons per cubic yard; stone as used 1.64 tons per cubic yard.

FIELD NOTES AND DATA.

ELECTRIC UNDERGROUND DEPARTMENT.

Conduit and Manhole Labor Cost.

Title: Laying 12 duct line from _____ street power plant to _____ street towers.

Company Number: X-1445.

Date: October to December 1919.

Statistics:

Total length of trench (exc.of manholes)	2115.0 Ft.
Average width of trench	3.0 Ft.
Average depth of trench	4.3 Ft.
Number of manholes	10

General Construction Notes:

Work done by _____ of _____ on the Cost Plus basis except the laying of the duct by a company man.

Force:

One general superintendent and one time-keeper, part time only. Average of three formemn, one night and day watchman, two carpenters, three sewermemn and twenty four laborers regularly at work. An engineer was on the job most of the time. The company had one duct-layer on the job all the time and the Underground Department superintendent visited the job continually, but no record was kept of his time.

The force was not well organized and lacked cohesion between the foremen and the men, thus causing considerable slackness in the work. This, however, was nothing exceptional to the then present class of common

labor. The labor consisted of Negroes and Italian sewermen, Negro common labor.

Physical Conditions:

Work was extremely difficult in spots due to obstructions encountered, also work was hindered by the presence of water. This latter item affected each of the various operations and is reflected in the unit costs. There was some variance to this however, and I have noted it in the analysis. Cold weather increased the cost considerably in December, due to the freezing of the ground and materials.

Excavation:

This in general consisted of removing a poor quality of brick paving, about eighteen inches of sand and the balance a sticky clay formation which had to be spaded. The excavation costs to be analyzed includd the cost of loading on wagons, also cost of general cleaning up of the street after completion of the work.

Hauling:

The hauling was practically all team haul over pawed streets with an average distance of one mile.

Concreteing:

Conduits:- The concrete was machine mixed with short haul except on the first trench which was over a block. The concrete was poured directly into the trench; no forms were used. This pouring had to be done in layers in order to place the duct.

Manholes:-

The concrete was machine mixed. Forms were built on the inside only. The walls were poured first, then the top, and the floor last. Placing and removing the forms was extremely costly in some cases because of the pumping of water prior to each operation. The reinforcing was placed irregularly in the top but was tied together.

Backfilling:

This was done with earth and stone. The cost was excessive in December due to the frozen material which had to be broken up before placing it in the opening.

Paving:

This covers the cost of cleaning the old brick and placing them over the trench and manholes. The cost was excessive due to insufficient labor. The work was very poorly done.

FIELD NOTES AND DATA.

The following notes and data were obtained in the field and do not include machinery costs.

Trench O-1: The orgional paving along this section was tar bound Macadam. Concrete was used in repaving. The work along this section was prolonged because of the river backing up high enough to flow from the street drain sewer into the trench. The trench was parallel to an old steam line which had to be removed, which did not interfere with the excavation.

Special work Number two should be added to this

trench. The cost of the work was excessive due to the action of the river mentioned above. The opening was ready to receive the duct about three thirty P.M., but due to a misunderstanding the work was not carried on that day, this postponement caused a two week delay in getting this section completed.

Trench 1-2:- This section was directly over an old rail-road trestle, and several heavy timbers and piles had to be removed from the trench. Water gave some trouble.

Trench 2-3:- Several piles had to be removed from this section. One side of an old manhole had to be removed and rebuilt in order to lay the duct line.

Trench 3-4:- Special Work Number one should be added to the cost of this part of the work. The special work consisted of going under two sewers at sreet intersection. These sewers, one of brick and the other of concrete, had to be tunneled under. The brick sewer rested on a concrete foundation and it was necessary to drill through this foundation under difficult conditions; water was always present in sufficient quantity to keep two power driven pitcher pumps operating.

Trench 4-5:- The digging along this section was mostly in sand. A catch basin drain pipe gave way and flooded the south end of the trench as the duct was being laid, and some time was wasted waiting for the City to repair the broken pipe.

Trench 5-6:- This section was delayed some due to having to cross other underground cables at _____ street bridge. ? After it was completed it was found that duct line lay over an old gas main. This caused an extra amount of work.

Trench:- 6-7: This section of the work was hampered by the cold weather. Before the paving gang moved on to this trench snow had covered the ground to a depth of one foot.

Trench 7-8:- Cold weather had frozen the ground to such a depth that it was difficult to dig the trench. Some time was lost waiting for warmer weather to pour the manhole.

Trench 8-9:- It was necessary to use cold cut and sledge hammer to excavate this trench. It was paved with concrete which froze before setting up. This paving was rejected by the company.

Trench 9-10:- Instead of going under the sewer at the street intersection the City engineer allowed the duct to be laid over it provided the duct line was fanned out to a two row depth rather than a three row. This required special care and slowed up the general progress of the work.

Manholes: The manholes were built with care, especially so when near the railroad tracks. Where the wall was near the track it was made extra thick. The tops of all manholes were made one foot thick and reinforced with steel.

TABULATED FIELD DATA ON EXCAVATION, LAYING DUCT, BACKFILLING AND PAVING.

TRENCH 0 - 1.

Length	355 ft 0 ins.	Earth excavated	170.0 Cu.Yds.		
Width	3 ft.6 ins.	Concrete used	44.0 " "		
Depth	6 ft.0 ins.				
Excavation.					
79½ Hours	Team	@.90¢	$ 71.55		
36 "	Carpenter	@.80¢	30.80		
68 "	Sewermen	@.50¢	40.80		
14 "	Labor	@.50¢	7.00		
488 "	"	@.45	219.60		
	Superintendence		77.50	437.25	
Laying Duct:					
3 Hours	Carpenter	@.80¢	1.60		
28 "	Sewermen	@.60¢	16.80		
11 "	Labor	@.50¢	5.50		
244½ "	"	@.45¢	110.03		
	Superintendence		37.20	171.13	
Backfilling:					
1 Hours	Labor	@.50¢	.50		
113 "	"	@.45¢	50.85		
	Superintendence		18.80	70.15	
Paving:					
17 Hours	Labor	@.50¢	8.50		
67 "	"	.45	30.15		
	Superintendence		13.99	52.64	
				731.17	
Workmens Compensation Insurance 1.77%				12.94	
Material, Laying Duct:					
43.75 Bbls.	Cement	2.67	116.81		
66.0 Tons	Stone	2.20	145.20		
34.2 "	Sand	.80	27.36		
5 Gal.	Gasoline	.24½	1.23		
Lumber, Etc.			5.00	295.60	
Backfilling:					
20.6 Tons	Stone	2.20	$5.32	45.32	
Paving:					
10.75 Bbls.	Cement	2.67	27.14		
16.8 Tons	Stone	2.20	36.96		
8.6 "	Sand	.80	6.88	70.98	1156.01
Contractors Profit 8%					92.48
3060 Ft. 4"Conduit		.07933¢			242.75
65 Hours	Labor	.54-5/8¢			35.44
			TOTAL		$ 1526.68

Trench 1 - 2.

Length	180 Ft. 6 in.	Earth Excavated	80.03 Cu.Yds.
Width	3 " 0 "	Concrete Used	30.50 " "
Depth	4 " 0 "		

Excavation:					
56½	Hours	Team	@.90¢	$ 50.95	
10	"	Carpenter	.80	8.00	
82	"	Sewermen	.60	49.20	
487	"	Labor	.45	219.15	
		Superintendence		49.30	376.60
Laying Duct:					
56	Hrs.	Sewermen	@.60	34.80	
393	"	Labor	.45	176.83	
		Superintendence		38.18	249.81
Backfilling:					
2	Hrs.	Labor	@.50	1.00	
149	"	"	.45	67.05	
		Superintendence		24.50	92.55
Paving:					
100	Hrs.	Labor	@.45¢	45.00	
		Superintendence		8.48	53.48
					772.46
Workmens Compensation Ins. 1.77%					13.67
		MATERIAL			
Laying Duct:					
27	Bbls.	Cement	@ 2.67	72.09	
46.25	T	Stone	2.20	101.75	
27	T	Sand	.80	21.60	
5	Gal.	Gasoline	.24½	1.23	
Lumber, etc.				5.00	201.67
Backfilling:					
11.12	Tons	Stone	2.20	24.46	
12	"	Sand	.80	9.60	34.06
Paving:					
1	Bbls.	Cement	2.67	2.67	2.67
					1024.53
Contractors Profit 8 %					81.96
2166 Ft. 4" Fiber Duct			@.07933		171.83
56	Hrs.	Labor	.54-5/8		30.05
			TOTAL		$ 1308.37

Trench 2 - 3 and 3 - 4.

Length	393 Ft. 0 Ins.	Earth excavated	174.33 Cu.Yds.
Width	3 Ft.	Concrete Used	66.4 " "
Depth	4 Ft.		

Team		112.50	
Labor		989.48	
Superintendence		207.00	1308.98
Workmens Compensation Ins. 1.77%			23.17
100.7 Tons	Stone @ 2.20	221.54	
54 "	Sand .80	43.20	
69 BBls.	Cement 2.82	194.58	
10 Gal.	Gas .24½	2.45	
Lumber, etc.		10.00	471.77
			1803.92
Contractors profit 8 %			144.31
4716 Ft. 4" Duct	@.07933¢		374.13
105 Hrs. Labor	.54-5/8		57.35
	TOTAL		$ 2379.70

Trench 4 - 5.

Length 329 Ft 6 Ins. Earth excavated 102.00 Cu.Yds.
Width 3 Ft. Concrete Used 38.06 " "
Depth 4 Ft.

Excavation:					
78	Hrs.	Team	@. 90¢	70.20	
38	"	Carpenter	. 80	22.40	
66	"	Sewermen	. 60	39.60	
42	"	Labor	. 50	21.00	
353	"	"	. 45	158.85	
		Superintendence		43.75	355.80
Laying Duct:					
8	Hrs	Carpenter	.80	6.40	
8	"	Sewermen	.60	4.80	
20½	"	Labor	.50	10.25	
206	"	"	.45	92.70	
		Superintendence		21.60	135.75
Backfilling:					
8	Hrs.	Labor	.50	4.00	
120	"	"	.45	54.00	
		Superintendence		11.42	69.42
Paving:					
42	Hrs.	Labor	.50	21.00	
109	"	"	.45	49.05	
		Superintendence		12.58	82.63
					643.60
Workmens Compensation Ins. 1.77 %					11.39
		MATERIAL.			
Laying Duct:					
39	Bbls.	Cement @	2.67	104.13	
58.6	T	Stone	2.20	129.32	
31.4	T	Sand	.80	25.12	
5	Gal.	Gas.	.24½	1.23	
Lumber, etc.				5.00	264.80
Backfilling:					
13.5	Ton	Stone	2.20	29.92	29.92
					949.71
Contractors Profit 8 %					75.97
2754 Ft. 4"		Duct @.07933			218.47
63	Hrs.	Labor .54-5/8			34.41
			TOTAL		1278.56

Trench 5 -6.

Length 225 Ft. 0 Ins. Earth excavated 135 Cu.Yds.
Width 3 Ft. Concrete Used 38 " "
Depth 5 Ft.

Excavation:					
69½	Hrs.	Team @	.90¢	62.53	
26	"	Carpenter.	.80	20.80	
54	"	Sewermen	.60	32.40	
40½	"	Labor	.50	20.25	
305½	"	"	.45	137.48	
		Superintendence		48.50	321.98
Laying Duct:					
44	Hrs.	Sewermen	.60	26.40	
17	"	Labor	.50	8.50	
313	"	"	.45	140.85	
		Superintendence		42.60	218.35
Backfilling:					
2½	Hrs.	Labor	.50	1.25	
79	"	"	.45	35.55	
		Superintendence		9.23	46.03
Paving:					
59	Hrs.	Labor	.50	29.50	
151	"	"	.45	67.95	
		Superintendence		24.09	121.64
					708.00
Workmens Compensation Ins.				1.77%	12.53

MATERIAL

Laying Duct:					
37	Bbls.	Cement @	2.67	98.79	
57.6	Tons	Stone	2.20	126.72	
31	"	Sand	.80	24.80	
5	Gal.	Gas	.24½	1.23	
Lumber, etc.				5.00	256.54
Backfilling:					
13.75	Ton	Stone	2.20	30.25	
14.7	"	Sand	.80	11.76	42.01
					1019.08
Contractors Profit 8%					81.53
2700 Ft. 4"Duct @.07933					214.19
55 Hrs. Labor .54-5/8					30.04
		TOTAL			1344.84

Trench 6 - 7.

Length 189 Ft.10½Ins. Earth excavated 74.5 Cu.Yds.
Width 3 Ft. Concrete Used 32.3 " "
Depth 3 Ft.6 Ins.

Excavation:					
59½	Hrs.	Team	@.90¢	53.55	
15	"	Carpenter	.80	12.00	
42½	"	Sewermen	.60	25.50	
34	"	Labor	.50	17.00	
202	"	"	.4 5	90.90	
		Superintendence		31.37	230.32
Laying Duct:					
3	Hrs.	Carpenter	.80	2.40	
27	"	Seweremen	.60	16.20	
6	"	Labor	.50	3.00	
181	"	"	.45	81.45	
		Superintendence		18.75	121.80
Backfilling:					
8	Hrs.	Sewermen	.60	4.80	
8	"	Labor	.50	4.00	
110	"	"	.45	49.50	
		Superintendence		10.88	69.18
Paving:					
25	Hrs.	Labor	.50	12.50	
181	"	"	.45	81.45	
		Superintendence		17.78	111.71
					533.01
Workmens Compensation Ins. 1.77%					9.44
		MATERIAL			
Laying Duct:					
33	BBls.	Cement	@2.67	88.11	
51.3	Tons	Stone	2.20	112.86	
25.55	"	Sand	.80	20.44	
5	Gal.	Gasoline	.24½	1.23	
Lumber,etc.				5.00	227.64
Backfilling:					
11.65	Tons	Stone	2.20	25.63	
18	"	Sand	.80	14.40	40.03
Paving:					
4.75	Bbls.	Cement	2.67	12.68	12.68
					822.80
Contractors Profit 8%					65.82
2280	Ft. 4"	Duct	@.07933		180.87
53	Hrs.	Labor	.54-5/8		28.95
			TOTAL	$	1098.44

Trench 7 - 8.

Length 183 Ft. Earth Excavated 81.4 Cu.Yds.
Width 3 Ft. Concrete Used 30.9 " "
Depth 4 Ft.

Excavation:					
54	Hrs.	Team	@ .90¢	48.60	
13	"	Carpenter	.80	10.40	
32	"	Sewermen	.60	19.20	
19½	"	Labor	.50	9.75	
211½	"	"	.45	95.18	
		Superintenedence		18.65	201.78
Laying Duct:					
23½	Hrs.	Sewermen	.60	13.50	
25	"	Labor	.50	12.50	
139	"	"	.45	62.55	
		Superintendence		12.57	101.12
Backfilling:					
2	Hrs.	Carpenter	.80	1.60	
2	"	Sewermen	.60	1.20	
6	"	Labor	.50	3.00	
58	"	"	.45	26.10	
		Superintendence		4.35	36.25
Paving:					
3	Hrs.	Sewermen	.60	1.80	
61	"	Labor	.45	27.45	
		Superintendence		4.63	33.87
					373.02
Workmens Compensation Ins. 1.77%					6.60

MATERIAL

Laying Duct:					
31	BBls.	Cement	@ 2.67	82.77	
40.7	Ton.	Stone	2.20	102.74	
25.18	"	Sand	.80	20.14	
5	Gal.	Gasoline	.24½	1.23	
Lumber,Etc./				5.00	211.88
Backfilling:					
11.2	Tons	Stone	2.20	24.64	24.64
Paving:					
5	BBLS.	Cement	2.67	13.35	
7.55	Tons	Stone	2.20	16.61	
408	"	Sand	.80	3.26	33.22
					649.36
Contractors Profit 8%					51.95
2196	Ft.	4" Conduit	@.07933		174.21
34	Hrs.	Labor.	.54-5/8		18.57
		TOTAL			$ 894.09

Length 225 Ft. Trench 8 - 9.
Width 3 Ft. Earth excavated 100 Cu. Yds.
Depth 4 Ft. Concrete Used 39 " "

Excavation:					
74	Hrs.	Team	@ .90¢	66.60	
8	"	Carpenter	.80	6.40	
65	"	Sewermen	.60	39.00	
65	"	Labor	.50	32.50	
432½	"	"	.45	198.63	
		Superintendence		54.40	397.53
Laying Duct:					
6	Hrs.	Carpenter	.80	4.80	
44	"	Sewermen	.60	26.40	
45	"	Labor	.50	22.50	
124	"	"	.45	55.80	
		Superintendence		18.50	128.00
Backfilling:					
22	Hrs.	Sewermen	.60	13.20	
30	Hrs.	Labor	.50	15.00	
189	"	"	.45	85.05	
		Superintendence		20.38	133.63
Paving:					
33	Hrs.	Labor	.50	16.50	
208	"	"	.45	93.60	
		Superintendence		20.36	130.46
					789.62
Workmens Compensation Ins. 1.77%					14.00

MATERIAL

Laying Duct:					
40	Bbls.	Cement	@ 2.67	106.80	
57.5	Tons	Stone	2.30	126.50	
29.7	"	Sand	.80	23.76	
5	Gal	Gasoline	.24½	1.23	258.29
Backfilling:					
14.2	Tons	Sand	.80	11.36	
27.4	"	Stone	2.30	60.28	71.64
					1133.55
Contractors Profit 8%					90.68
2712	Ft. 4"	Duct	.07933¢		215.14
68	Hrs.	Labor	.54-5/8		37.14
			TOTAL		1476.51

Trench 9 - 10.

Length 225 Ft. 9 Ins. Earth Excavated 100.3 Cu.Yds.
Width 3 Ft. Concrete used 38.2 " "
Depth 4 Ft.

Excavation:				
110	Hrs. Team	@1.60¢	110.00	
6	" Carpenter	.80	4.80	
63	" Sewermen	.60	37.80	
37	" Labor	.50	18.50	
577	" "	.45	259.65	
	Superintendence		69.80	500.55
Laying Duct:				
40	Hrs. Sewermen	.60	24.00	
10	" Labor	.50	5.00	
211	" "	.45	94.95	
	Superintendence		39.91	163.86
Backfilling:				
2	Hrs. Sewermen	.60	1.20	
221	" Labor	.45	99.45	
	Superintendence		32.11	132.76
Paving:				
6	Hrs. Sewermen	.60	3.60	
36	" Labor	.45	16.20	
	Superintendence		2.79	22.59
				819.76
Workmens Compensation Ins. 1.77%				14.51

MATERIAL

Laying Duct:				
40 Bbls.	Cement	2.67	106.80	
62.4 Tons	Stone	2.20	137.16	
30	" Sand	.80	24.00	267.96
Backfilling:				
43 Tons	Stone	2.20	94.60	
15.5	" Sand	.80	12.40	107.00
Paving:				
12.4 Bbls.	Cement	2.67	33.11	
12.7 Tons	Stone	2.20	27.94	
6.37	" Sand	.80	5.10	66.15
				1275.38
Contractors Profit 8 %				102.03
2719 Ft. 4"Duct		.07933		215.70
55	Hrs. Labor	.54-5/8		30.09
			TOTAL	1623.20

SPECIAL WORK NO.1.

Team	$ 37.80	
Labor	356.50	
Superintendnece	288.89	683.19
Workmens Compensation Ins. 1.77%		12.09

MATERIAL

12	Bbls.	Cement	@ $2.82	33.84	
57.5	Tons	Stone	2.20	126.50	
30.8	"	Sand	.80	24.64	
20	Gal.	Gasoline	.24½	4.90	
Lumber, Etc.				20.00	209.88
					905.16
Contractors Profit 8 %					72.41
			TOTAL		$ 977.57

Note: This amount is to be added to the cost of trench work between manholes 3 and 4.

SPECIAL WORK NO. 2.

Excavation:					
33	Hrs.	Team	@ .90	29.70	
187½	"	Sewermen	.60	112.50	
83½	"	Labor	.50	41.75	
344½	"	"	.45	155.03	
37	"	Carpenter	.80	45.60	
		Superintendence		154.00	538.58
Laying Duct:					
31	Hrs.	Labor	.50	10.50	
154	"	"	.45	69.30	
		Superintendance		40.25	120.05
Backfilling:					
44	Hrs.	Sewermen	.60	26.40	
186	"	Labor	.45	83.70	
		Superintendence		53.00	163.10
Paving:					
20	Hrs.	Labor	.50	10.00	
131	"	"	.45	58.95	
		Superintendance		35.85	104.80
					926.53
Workmens Compensation Ins. 1.77%					16.40

MATERIAL

30	Gal.	Gasoline	.24½	4.90	
Meals				11.40	
13	Bbls.	Cement	2.67	34.71	
51.4	Tons	Stone	2.20	113.08	
10.7	"	Sand	.80	8.56	
Lumber				10.00	182.65
					1125.58
Contractor Profit 8%					90.05
			TOTAL	$	1215.63

MANHOLE NO. 1.

Inside dimensions: 6'-0" x 6'-7" x 9'-0"
Thickness of walls 8 inches.
Excavation 25.8 Cu.Yds.
Concrete Used 7.98 Cu.Yds.

Excavation:					
35	Hrs.	Team	@.90	31.50	
60	"	Sewermen	.60	36.00	
60	"	Labor	.45	27.00	
		Superintendence		40.20	134.70
Forms:					
32	Hrs.	Carpenter	.80	25.60	
8	"	Labor	.45	3.60	
		Superintendence		13.40	42.60
Pouring:					
11	Hrs.	Sewermen	.60	6.60	
5	"	Labor	.50	2.50	
62	"	"	.45	27.90	
		Superintendence		14.40	51.40
Setting Steel:					
6	Hrs.	Labor	.45	2.70	
		Superintendence		2.00	4.70
Paving:					
9	Hrs.	Labor	.50	4.50	
25	"	"	.45	11.25	
		Superintendence		11.30	27.05
Wrecking Forms:					
12	Hrs.	Carpenter	.80	9.60	
1	"	Labor	.45	.45	
		Superintendence		4.32	14.37
					374.82
Workmen's Compensation Ins. 1.77%					4.87
		MATERIAL.			
6.74	Tons	Sand	.80	5.39	
11.59	"	Stone	2.20	25.50	
9.7	Bbls.	Cement	2.67	25.90	
539	Lbs.	Steel	3.32cwt.	17.89	
Lumber				21.47	96.15
					375.84
Contractors Profit 8%					30.07
1 Manhole Frame & Cover					36.00
			TOTAL		$ 441.91

MANHOLE NO. 2

Inside dimensions 6'-0" x 6'-0" x 7'-6".
Walls eight inches thick.
Earth excavated 25.9 Cu.Yds.
Concrete used 8.13 " "

Excavation:					
25	Hrs.	Team	@.90¢	22.50	
15	"	Carpenter	.80	12.00	
33	"	Sewermen	.60	19.80	
20	"	Labor	.50	10.00	
50	"	"	.45	22.50	
		Superintendence		63.50	150.30
Erecting & Wrecking Forms:					
47	Hrs.	Carpenter	.80	37.60	
20	Hrs	Labor	.45	9.00	
		Superintendence		28.32	74.92
Pouring Concrete:					
5	Hrs.	Sewermen	.60	3.00	
93½	"	Labor	.45	41.08	
		Superintendence		30.85	75.93
Setting steel:					
8	Hrs.	Labor	.45	3.60	
		Superintendence		3.38	6.98
Paving:					
27	Hrs.	Labor	.45	12.15	
10	"	"	.50	5.00	
		Superintendence		5.50	22.65
					330.78
Workmens Compensation Ins. 1.77 %					5.85

MATERIAL

12.28	Tons	Stone	@2.30	27.02	
6.37	"	Sand	.80	5.10	
8.51	Bbls.	Cement	2.67	22.72	
5.42	Cwt.	Steel	3.32	17.99	
		Lumber		20.01	92.84
					429.47
Contractors Profit 8%					34.36
1 Manhole frame & cover					36.00
				TOTAL	$ 499.83

MANHOLE NO.3.

Inside dimensions: 6 x 7 x 9 Ft.
Walls 8 inches thick.
Earth excavated 28.9 Cu.Yds.
Concrete used 11.27 " "

Excavation:					
35	Hrs.	Team	@ .90 ¢	31.50	
61½	"	Sewermen	.60	36.90	
121	"	Labor	.45	54.45	
		Superintendence		76.00	198.85
Form Work:					
41½	Hrs.	Carpenter	.80	33.20	
1	"	Labor	.45	.45	
		Superintendence		17.54	51.19
Pouring:					
5	Hrs.	Labor	.50	2.50	
47	"	"	.45	21.15	
		Superintendence		10.79	34.44
Setting Steel:					
10	Hrs.	Labor	.45	4.50	
		Superintendence		4.13	8.63
Paving:					
25	Hrs.	Labor	.45	11.25	
15	"	"	.45	7.50	
		Superintendence		16.70	35.45
					328.56
Workmens Compensation Ins. 1.77%					5.82
		MATERIAL			
8.81	Tons	Sand	@ $ .80	7.05	
17.4	"	Stone	2.20	38.28	
11.27	Bbl.	Cement	2.67	30.09	
7.25	Cwt.	Steel	3.32	24.07	
		Lumber		24.17	123.66
					458.04
Contractors Profit 8%					36.64
1 Manhole frame & cover					36.00
			TOTAL		$530.68

MANHOLE NO. 4.

Inside dimensions: 6 x 6½ x 8½ Ft.
Walls 8 inches thick.
Earth excavated 23.5 Cu.Yds.
Concrete used 9.3 " ".

Excavation:					
20	Hrs.	Team	@ .90¢	18.00	
5	"	Carpenter	.80	4.00	
45	"	Sewermen	.60	27.00	
121½	"	Labor	.45	54.68	
		Superintendence		71.00	174.68
Forms:					
		Labor		44.25	
		Superintendence		25.34	69.59
Pouring:					
		Labor		39.85	
		Superintendence		25.34	65.19
Setting Steel:					
		Labor		5.33	
		Superintendence		3.74	9.07
Paving:					
		Labor		10.30	
		Superintendence		9.06	19.36
					337.88
Workmens Compensation Ins. 1.77%					5.97

MATERIAL.

7.17	Ton	Sand	@ .80	5.74	
13.9	"	Stone	2.20	30.58	
9.18	Bbl.	Cement	2.82	25.89	
5.92	Cwt.	Steel	3.32	19.65	
		Lumber		21.46	103.32
					447.17
Contractors Profit 8%					35.77
1 Manhole frame & cover					36.00
			TOTAL		$ 518.94

MANHOLE NO. 5.

Inside dimensions: 6'-0" x 8'-10" x 5'-6".
Walls 12 inches thich.
Earth excavated 25.9 Cu.Yds.
Concrete used 11.37 " "

Excavation:			
	Team	18.00	
	Labor	60.95	
	Superintendence	28.80	107.75
Forms:			
	Labor	44.55	
	Superintendence	15.17	59.72
Pouring:			
	Labor	39.00	
	Superintendence	15.97	54.97
Setting Steel:			
	Labor	2.50	
	Superintendence	1.07	3.57
Paving:			
	Labor	3.80	
	Superintendence	2.24	6.04
			232.05
Workmens Compensation Ins. 1.77%			4.11

MATERIAL.

8.88	Tons	Sand	.80	7.10	
17.06	"	Stone	2.20	37.53	
9.84	Bbl.	Cement	2.67	26.17	
4.94	Cwt,	Steel	3.36	16.41	
		Lumber		20.74	107.95
					344.11
Contractors Profit 8%					27.53
1 Manhole frame & cover					36.00
			TOTAL	$	407.64

MANHOLE NO. 6.

Inside dimensions: 6 x 8½ x 5 Ft.
Walls 10 inches thick.
Earth excavated 21.8 Cu.Yds.
Concrete used. 9.0 " "

Excavation:				
	Labor		49.86	
	Team		18.00	
	Superintendence		31.86	94.61
Forms;				
	Labor		40.60	
	Superintendence		15.56	56.16
Pouring:				
	Labor		28.95	
	Superintendence		17.13	46.08
Setting Steel;				
	Labor		3.60	
	Superintendence		1.05	4.65
Paving:				
	Labor:		13.65	
	Superintendence		3.76	17.41
				218.91
Workmens Compensation Ins. 1.77%				3.87

MATERIAL.

7.18	Ton	Sand	.80	5.74	
13.9	"	Stone	2.20	30.58	
9	Bbl.	Cement	2.67	24.03	
5.83	Cwt.	Steel	3.38	19.36	
		Lumber		22.74	102.45
					325.33
Contractors Profit 8%					26.02
1 Manhole frame & cover					36.00
				TOTAL $	387.35

MANHOLE NO. 7.

Inside dimensions: 6 x 5 x 8½ Ft.
Walls 11 inches thick.
Earth excavated 22.6 Cu.Yds.
Concrete used 9.3 " "

Excavation:			
	Labor	64.45	
	Team	17.10	
	Superintendence	34.65	116.20
Forms;			
	Labor	26.70	
	Superintendence	34.83	61.53
Pouring:			
	Labor	36.10	
	Superintendence	17.47	53.57
Setting steel:			
	Labor	3.20	
	Superintendence	1.67	4.87
Paving:			
	Labor	18.65	
	Superintendence	10.90	29.55
			265.72
Workmens Compensation Ins. 1.77%			4.70

MATERIAL.

7.52	Tons	Sand	.80	6.02	
14.48	"	Stone	2.20	31.86	
9.76	Bbl.	Cement	2.67	26.05	
5.83	Cwt.	Steel	3.32	19.35	
		Lumber		19.28	103.56
					372.98
Contractors Profit 8%					29.84
1 Manhole frame & cover					36.00
				TOTAL $	438.82

MANHOLE NO. 8.

Inside dimensions: 6 x 9 x 5 Ft.
Walls 10 inches thick.
Earth excavated 21.9 Cu.Yds.
Concrete used. 8.7 " "

Excavation:			
	Team	18.00	
	Labor	44.95	
	Superintendence	16.80	79.75
Forms:			
	Labor	31.40	
	Superintendence	5.30	36.70
Pouring:			
	Labor	25.35	
	Superintendence	8.27	33.62
Setting Steel:			
	Labor	2.40	
	Superintendence	.65	3.05
Paving:			
	Labor	10.15	
	Superintendence	1.15	11.30
			164.42
Workmens Compensations Ins. 1.77%			2.91

MATERIAL.

7.01	Tons	Sand	.80	5.61	
13.67	"	Stone	2.20	30.07	
8.25	Bbl.	Cement	2.67	22.03	
5.83	Cwt.	Steel	3.32	19.35	
		Lumber		19.28	96.34
					263.67
Contractors Profit 8 %					21.09
1 Manhole frame & cover					36.00
			TOTAL		$ 320.76

MANHOLE No.9.

Inside dimensions: 6 x 5 x 8 Ft.
Walls 9 inches thick.
Earth excavated 14.0 Cu.Yds.
Concrete used 8.2 " "

Excavation:			
	Team	21.00	
	Labor	33.75	
	Superintendence	18.58	73.33
Forms:			
	Labor	37.60	
	Superintendence	16.07	53.67
Pouring:			
	Labor	23.50	
	Superintendence	6.22	28.72
Setting steel:			
	Labor	3.60	
	Superintendence	.80	4.40
Paving:			
	Labor	23.35	
	Superintendence	3.87	27.22
			187.34
Workmens Compensation Ins. 1.77%			3.32

MATERIAL.

6.01	Tons	Sand	.80	4.81	
11.66	"	Stone	2.20	25.65	
8.75	Bbl.	Cement	2.67	20.67	
5.83	Cwt	Steel	3.32	19.35	
		Lumber		20.67	93.84
					284.50
Contractors Profit 8%					22.76
1 Manhole Frame & Cover					36.00
			TOTAL		$ 343.26

COST ANALYSIS.

The cost analysis compiled for the job from the preceeding field notes and data is exclusive of the item of superintendence, which will be expressed as a percentage of the total expenditure for labor including carpenters, sewermen and common laborers.

In order to get away from the variable factor of the price of labor the analysis should be expressed in some such term which can be reduced to present price of labor. I have used the English unit system for expressing the unit of work and the number of hours required per unit. The rate given in the field data will not have any bearing on the method adopted and to apply the data to current price of labor all that is necessary is the compute the base rate, i.e., the average price of the various classes of labor involved.

COST OF TRENCH EXCAVATION.

Trench & Length.	Class of Workmen	No. Hrs.	Rate/ Hour	Total Cost.	No. of Units	Unit	Cost per Unit	Hours per Unit.
1 - 2	Carpenter	10	.80	8.00	80.03	Cu·Yd.	.10	0.12
180.2'	Sewermen	82	.60	49.20			.61	1.02
	Laborers	487	.45	219.15			2.73	6.08
	Total	579	.477	276.35	80.03		3.45	7.22
	Men digging only.	569	.471	268.35			3.34	7.10
4 - 5								
239½'	Carpenters	38	.80	22.40	102.0	Cu.Yd.	.21	.27
	Sewermen	66	.60	39.60			.38	.64
	Laborers	42	.50	21.00			.20	.41
	Laborers	353	.45	158.85			1.56	3.46
	Total	489	.494	241.85			2.35	4.78
	Men digging only.	461	.476	219.45			2.15	4.51
5 - 6	Carpenter	26	.80	20.80	125.0	Cu.Yd.	.16	.20
225'	Sewermen	54	.60	32.40			.26	.43
	Laborers	40	.50	20.00			.15	.31
	Laborers	306	.45	137.48			1.11	2.46
	Total	425	.495	210.68			1.68	3.40
	Men digging only	400	.475	190.13			1.52	3.20
6 - 7	Carpenter	15	.80	12.00	74.5	Cu.Yd.	.16	.20
189'10½"	Sewermen	42½	.60	25.50			.34	.56
	Laborers	34	.50n	17.00			.22	.45
	Laborers	302	.45	90.90			1.22	2.71
	Total	293½	.495	145.40			1.94	3.92
	Men digging only	278½	.479	133.40			1.78	3.72

Trench & Length	Class of Workmen	No. Hrs.	Rate/ Hour	Total Cost	No.of Units	Unit	Cost per Unit	Hours per Unit.
7 - 8	Carpenter	13	.80	10.40	81.4	Cu.Yds.	.12	.15
183'	Sewermen	32	.60	19.20			.23	.39
	Laborers	20	.50	10.00			.12	.24
	Laborers	211	.45	95.18			1.16	2.59
	Totalm	276	.488	134.78			1.64	3.37
	Men digging only	263	.472	124.38			1.52	3.32
9 - 10	Carpenter	6	.80	4.80	100.3	Cu.Yds.	.05	.06
	Sewermen	63	.60	37.80			.38	.62
	Laborers	37	.50	18.50			.18	.36
	Laborers	577	.45	259.65			2.59	5.75
	Total	683	.469	320.75			3.20	6.79
	Men digging only	677	.467	315.95			3.15	6.75

NOTE: Trench 9 - 10 was difficult due to frozen ground and should be classified as rock excavation.

Cost Of Hauling Excavated Earth With Teams (Average 1 Mile)

Trench	Class of Labor	No. Hrs	Rate/ Hour	Total Cost	No.of Units	Unit	Cost per Unit	Hours per Unit.
1 *2	Teams	56.5	.90¢	50.95	50.0	Cu.Yd.	1.02	1.13
4 -5	Teams	78	.90	70.20	60.2		1.16	1.29
5 - 6	Teams	69.5	.90	62.55	61.7		1.01	1.12
6 - 7	Teams	59.5	.90	53.55	52.8		1.01	1.12
7 - 8	Teams	54.0	.90	48.60	50.8		.95	1.06
8 - 9	Teams	74	.90	66.60	65.2		1.02	1.13
9 - 10	Teams	110	1.00	110.00	63.5		1.76	1.76
Total & Average		501.5		462.45	403.2		1.147	1.24

BACKFILLING WITH STONE AND EARTH

Treanh 6	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	No.of Units	Unit	Cost per Unit	Hours per Unit
0 - 1	Laborers	114	.45	51.30	104.8	Cu.Yd	.49	1.09
5 - 6	Laborers	2½	.50	1.25	66.7			
	Laborers	79	.45	35.55				
	Total	81.5	.451	36.80	66.7		.55	1.22
7 - 8	Laborers	10	.50	5.00	40.6			
	Laborers	58	.45	26.10				
	Total	68	.457	31.10	40.6		.77	1.67

Note: The above three jobs were the only ones giving the cost of backfilling under fair conditions. The cost of the other trench sections varied between $1.50 and $3.90, the latter high price due to the earth and stone piled on the sides being frozen.

MIXING AND POURING CONCRETE.

Trench	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	No. of Units	Unit	Cost per Unit	Hours per Unit.
1 - 2	Sewermen	58	.60	34.80	30.5	Cu.Yds.	1.14	1.90
	Laborers	393b	.45	176.85			5.79	12.88
	Total	451		211.65			6.93	14.78
4 -5	Carpenter	8	.80	6.40	38.06	Cu.Yds.	.16	.21
	Sewermen	8	.60	4.80			.12	.21
	Laborers	20.5	.50	10.25			.27	.53
	Laborers	206	.45	92.70			3.43	5.41
	Total	242.5		114.15			3.98	6.36
5 - 6	Sewermen	44	.60	26.40	38	Cu.Yds.	.69	1.15
	Laborers	17	.50	8.50			.22	.44
	Laborers	313	.45	140.85			3.70	8.24
	Total	374		175.75			4.61	9.83
6 - 7	Carpenter	3	.80	2.40	32.3	Cu.Yds.	.07	.09
	Sewermen	27	.60	16.20			.50	.83
	Laborers	6	.50	3.00			.09	.19
	Laborers	181	.45	81.45			2.52	5.60
	Total	217		103.05			3.18	6.71
7 - 8	Sewermen	22.5	.60	13.50	30.9	Cu.Yds.	.44	.73
	Laborers	25	.50	12.50			.40	.81
	Laborers	139Y	.45	62.55			2.02	4.49
		186.5		88.55			2.86	6.03
8 - 9	Carpenter	6	.80	4.80	38.82	Cu.Yd.	.12	.15
	Sewermen	44	.60	26.40			.68	1.13
	Laborers	45	.50	22.50			.57	1.15
	Laborers	125	.45	55.80			1.43	3.22
		220		109.50			2.80	5.65
9 - 10	Sewermen	40	.60	24.00	38.2	Cu.Yd.	.62	1.04
	Laborers	10	.50	5.00			.13	.26
	Laborers	211	.45	94.95			2.48	4.33
	Total	261		123.95			3.23	5552

Note: Haul from mixer to trench will average 1 block.

COST OF LAYING 4 INCH DUCT.

Trench	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	No.of Units	Unit	Cost per Unit	Hrs.per Unit.
0 - 1	Laborer	65	.54-5/8	35.44	3.060	M.Ft.	11.58	21.24
1 - 2	Laborer	56	.54-5/8	30.05	2.166	" "	13.87	25.85
2-3-4-	Laborer	105	.54-5/8	57.35	4.716	" "	12.17	22.26
4 - 5	Laborer	63	.54-5/8	34.41	2.754	" "	12.49	22.90
5 - 6	Laborer	55	.54-5/8	30.04	2.700	" "	11.13	20.37
6 - 7	Laborer	53	.54-5/8	28.95	2.280	" "	12.69	23.24
7 - 8	Laborer	34	.54-5/8	18.57	2.196	" "	8.45	15.48
8 - 9	Laborer	68	.54-5/8	37.14	2.712	" "	13.69	25.07
9 - 10	Laborer	55	.54-5/8	30.09	2.719	" "	11.06	20.22
Total & Average		554		302.04	25.299		11.94	21.90

Note: The 4" fibre duct was laid by a company man who did nothing but lay the duct. No contractors overheads were applied to the labor or material cost in the bill presented the Company by the Contractor.
The fibre duct comes in 5'0" lengths with ferrelled ends.

COST OF PAVING.

Trench	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	No.of Units	Unit	Cost per Unit	Hrs. per Unit.
1 -2	Laborers	100	.45	45.00	60.0	Sq.Yd.	.75	1.66
4 - 5	Laborers	42	.50	21.00	76.7	"	.274	.55
	Laborers	109	.45	49.05			.640	1.43
Total & Aver.		151	.464	70.05			.914	1.98
5 - 6	Laborers	59	.50	29.50	74.1	"	.39	.79
	Laborers	151	.45	67.95			.917	2.04
Total & Average		210	.464	97.45			1.307	2.83
6 - 7	Laborers	25	.50	12.50	63.3	"	.19	.40
	Laborers	181	.45	81.45			1.28	2.86
Total & Average		206	.456	93.95			1.47	3.26

Note: One man cleaning Brick and one man laying Brick most of the time. Labor forces insufficient.

EXCAVATION OF MANHOLES.

Man-hole	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	No.of Units	Unit	Cost per Unit	Hrs.per UNIT.
#1	Sewermen	60	.60	36.00	25.8	Cu.Yd.	1.39	2.32
	Laborers	60	.45	27.00			1.04	2.32
	Total & Average	120	.525	63.00			2.43	4.64
#2	Carpenter	15	.80	12.00	25.9	"	.46	.57
	Sewermen	33	.60	19.80			.76	1.27
	Laborers	20	.50	10.00			.38	.77
	Laborers	50	.45	23.50			.86	1.93
	Total	118	.545	64.30			2.46	4.54
	Diggers only.	103	.508	52.30			2.00	3.97
#3	Sewermen	61.5	.60	36.90	28.9	"	1.27	2.12
	Laborers	121.0	.45	54.45			1.88	4.18
	Total	182.5	.505	91.35			3.15	6.30
#4	Carpenter	5	.80	4.00	23.5	"	.17	.21
	Sewermen	45	.60	27.00			1.14	1.91
	Laborers	121.5	.45	54.68			2.33	5.17
	Total	171.5	.558	85.68			3.64	7.29
	Diggers only	166.5	.55	81.68			3.47	7.08
#5	Carpenter	12	.80	9.60	25.9	"	.37	.46
	Sewermen	54	.60	32.40			1.25	2.08
	Laborers	1	.50	.50			.02	.03
	Laborers	41	.45	18.45			.71	1.58
	Total	108	.564	60.95			2.35	4.15
	Diggers only	96	.535	51.35			1.98	3.69
#6	Carpenter	6	.80	4.80	21.8	"	.22	.27
	Sewermen	17	.60	10.20			.46	.77
	Laborers	1	.50	.50			.02	.04
	Laborers	65	.45	29.25			1.34	2.98
	Total	89	.503	44.75			2.04	4.06
	Diggers only	83	.481	39.95			1.82	3.81
#7	Sewermen	29	.60	17.40	22.6	"	.77	1.28
	Laborers	23	.50	11.50			.51	1.02
	Laborers	79	.45	35.55			1.57	3.49
	Total	131	.492	64.45			2.85	5.79

EXCAVATION OF MANHOLES.

Man-hole	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	No.of Units	Unit	Cost per Unit	Hours per unit,
#8	Carpenter	21	.80	17.80	21.7	Cu.Yd,	.03	1.04
	Sewermen	23	.60	13.80			.63	1.06
	Laborers	22	.50	11.00			.51	1.01
	Laborers	43	.45	19.35			.89	1.98
	Total	89	.505	44.95			2.06	4.09
	Diggers only	88	.511	44.15			2.03	4.05
#9	Sewermen	26	.60	15.60	20.0	" ""	.78	1.30
	Laborers	8	.50	4.00			.20	.40
	Sewermen	10	.65	6.50			.32	.50
	Laborers	17	.45	7.65			.38	.85
	Total	61	.553	33.75			1.69	3.05

Note: In trenches 1 - 4 there was considerable trouble due to water and some piling.
There was a bad cave-in on No.4.
Trenches 5 - 9 were all fairly dry and not troublesome.
Trench No.9 needed no bracing. No cave-ins.

HAULING EXCAVATED MATERIAL FROM MANHOLES.
(Average haul of one mile)

Man-hole	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	No.Of Units	Unit	Cost per Unit	Hours per Unit
#1	Teams	35	.90	31.50	25.8	Cu.Yd.	1.22	1.35
#2	"	25	.90	22.50	25.9	" "	.86	.96
#3	"	35	.90	31.50	28.9	" "	1.09	1.21
#4	"	20	.90	18.00	23.5	" "	.76	.85
#5	"	20	.90	18.00	25.9	" "	.69	.77
#6	"	20	.90	18.00	21.8	" "	.82	.91
#7	"	19	.90	17.10	22.6	" "	.75	.84
#8	"	18	1.00	18.00	21.7	" "	.83	.83
TOTALS		192		174.60	196.1		.89	.98

PLACING AND WRECKING MANHOLE FORMS.

Man-hole	Class of Labor	No. Hrs.	Rate/ Hr.	Total Cost	No. of Units	Unit	Cost per Unit	Hours Cost per Unit
#1	Carpenter	32	.80	25.60	246.6	Sq.Ft.	.10	.12
	Laborers	8	.45	3.60		of	.01	.03
	Total	40	.703	29.20		Form Surf-	.11	.16
#2	Carpenters	39	.80	31.20	208.8	ace.	.15	.18
	Laborers	14	.45	6.30			.03	.06
	Total	53	.706	37.50			.18	.24
#3	Carpenters	28.5	.80	22.80	254.7		.09	.11
#4	Carpenters	46	.80	36.80	234.9		.16	.20
	Laborers	13	.45	5.85			.02	.05
	Total	59	.723	42.65			.18	.25
#5	Carpenters	38	.80	30.40	220.5		.14	.17
#6	Carpenters	40	.80	32.00	207.9		.15	.19
	Sewermen	3	.60	1.80			.01	.02
	Laborers	8	.45	3.60			.02	.04
	Total	51	.733	37.40			.18	.25
#7	Carpenters	26	.80	20.80	224.1		.09	.12
	Sewermen	3	.60	1.80			.01	.01
	Laborers	2	.45	.90			.01	.01
	Total	31	.758	23.50			.11	.14
#8	Carpenters	34	.80	27.20	209.7		.13	.16
#9	Carpenters	40	.80	32.00	199.35		.16	.20

Note: Costs more or less high due to pumping, all manholes having some water in them after excavation.

COST OF MIXING AND POURING CONCRETE IN MANHOLES.

Man-hole	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	Quantity	Unit	Cost per Unit	Hour per Unit.
#1	Serwermen	11	.60	6.60	7.98	Cu.Yds,	.83	1.38
	Laborers	62	.45	27.90	"	"	3.50	7.76
	Laborers	5	.50	2.50	"	"	.69	.63
	Total	78	.513	40.00			5.02	9.77
#2	Sewermen	5	.60	3.00	8.13	"	.37	.62
	Laborers	93.5	.45	42.08			5.18	11.50
	Total	98.5	.458	45.08			5.55	12.12
#3	Laborers	5	.50	2.50	11.27	"	.22	.44
	Laborers	47	.45	21.15			1.87	4.17
	Total	52	.455	23.65			2.09	4.61
#4	Sewermen	7	.60	4.20	9.3	"	.45	.75
	Laborers	2	.60	1.20			.13	.22
	Laborers	77	.45	34.65			3.73	8.38
	Total	86	.465	40.05			4.31	9.25
#5	Sewermen	2	.60	1.20	11.37	"	.11	.17
	Laborers	9.	.50	4.50			.39	.79
	Laborers	74	.45	33.30			2.93	6.51
	Total	85	.459	39.00			3.43	7.47
#6	Sewermen	7	.60	4.20	9.00	"	.47	.78
	Laborers	55	.45	24.75			3.75	6.11
	Total	62	.467	28.95			3.22	6.89
#7	Sewermen	11.	.60	6.60	9.26	"	.71	1.19
	Laborers	5	.50	2.50			.59	.54
	Laborers	60	.45	27.00			2.92	6.48
	Total	76	.514	39.10			4.22	8.20
#8	Sewermen	10	.60	6.00	8.7	"	.69	1.15
	Laborers	53	.45	23.85			2.74	6.09
	Total	63	.474	29.85			3.43	7.24

COST OF REMOVING FORMS FROM MANHOLE.

Man-hole	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	Quantity	Unit	Cost per Unit	Hours per Unit
#1	Carpenter	12	.80	9.60	246.6	Sq.Ft.	.039	.048
	Laborers	1	.45	.45			.001	.003
	Total	13	.773	10.05			.040	.051
#2	Carpenter	8	.80	6.40	208.8	" "	.030	.038
	Laborer	6	.45	2.70			.013	0030
	Total	14	.65	9.10			.043	.068
#3	Carpenter	13	.80	10.40	254.7	" "	.043	.062
	Laborer	1	.45	.45			.001	.003
	Total	14	.775	10.85			.044	.065
#4	Carpenter	2	.80	1.60	234.9	" "	.007	.008
#5	Carpenter	16	.80	12.80	220.5	" "	.058	.072
	Laborer	3	.45	1.35			.006	.013
	Total	19	.744	14. 15			.064	.085
#6	Carpenter	4	.80	3.20	207.9	" "	.015	.015
#7	Carpenter	4	.80	3.20	224.1	" "	.014	.017
#8	Sewermen	4	.60	2.40	209.7	" "	.011	.019
	Laborer	4	.45	1.80			.008	.019
	Total	8	.525	4.20			.019	.038
#9	Carpenter	7	.80	5.60	199.35	" "	.028	.035

COST OF PLACING STEEL REINFORCING.

Man-hole	Class of Labor	No. Hrs.	Rate Hour	Total Cost	Qualtity	Unit	Cost per Unit	Hours per Unit
#1	Laborer	6	.45	2.70	5.39	Cwt.	.50	1.11
#2	Laborer	8	.45	3.60	5.42	"	.66	1.48
#3	Laborer	10	.45	4.50	7.25	"	.62	1.38
#4.	Carpenter	3	.80	2.40	5.92	"	.41	.50
	Laborer	6½	.45	2.93		" "	.49	1.91
	Total	9½	.62	5.33		"	.90	2.41
#5.	Carpenter	2	.80	1.60	4.94	"	.32	.40
	Laborer	2	.45	.90		"	.18	.40
	Total	4	.62	2.50		"	.50	.80
#6	Laborer	8	.45	3.60	5.83	"	.61	1.37
#7	Carpenter	4	.80	3.20	5.83	"	.54	.68
#1	Laborer	6	.45	2.70	3.23	Cu.Yds.	.83	1.86
#2	Laborer	8	.45	3.60	3.36	" "	1.07	2.38
#3	Laborer	10	.45	4.50	4.18	" "	1.08	2.39
#4	Carpenter	3	.80	2.40	3.07	" "		
	Laborer	6½	.45	2.93				
	Total	9½	.	5.33			1.73	3.09
#5	Carpenter	2	.80	1.60	4.94	" "		
	Laborer	2	.45	.90				
	Total	4	.62	2.50		" "	.72	1.14
#6	Laborer	8	.45	3.60	3.16	" "	1.14	2.53
#7	Carpenter	4	.80	3.20	2.38	" "	1.34	1.68

COST OF PAVING MANHOLES.

Man-hole	Class of Labor	No. Hrs.	Rate/ Hour	Total Cost	Quantity	Unit	Cost per Unit	Hours per Unit
#1	Laborers	9	.50	4.50	9.11	Sq.Yd.	.48	.99
	Laborers	25	.45	11.25			1.37	2.74
	Total	34	.463	15.75			1.76	3.73
#2	Laborers	10	.50	5.00	9.5	" "	.53	1.01
	"	27	.45	12.15			1.28	2.84
	Total	37	.463	17.15			1.81	3.85
#3	Laborers	15	.50	7.50	10.3	" "	.74	1.47
	"	25	.45	11.25			1.10	2.45
	Total	40	.469	18.75			1.84	3.92
#4	Laborers	8	.50	4.00	7.96	" "	.50	1.00
	"	14	.45	6.30			.79	1.76
	Total	22	.468	10.30			1.29	2.76
#5	Laborers	4	.50	2.00	9.16	" "	.22	.44
	"	4	.45	1.80			.19	.44
	Total	8	.475	3.80			.41	.88
#6	Laborers	12	.50	6.00	7.61	" "	.79	1.58
	"	17	.45	7.65			1.00	2.23
	Total	29	.471	13.65			1.79	3.81
#7	Laborers	13	.50	6.50	7.61	" "	.85	1.71
	"	27	.45	12.15			1.60	3.55
	Total	40	.466	18.65			2.45	5.26
#8	Laborers	5	.50	2.50	7.61	" "	.33	.66
	"	17	.45	7.65			1.00	2.23
	Total	22	.461	10.15			1.33	2.89
#9	Laborers	8	.50	4.00	7.61	" "	.52	1.05
	"	43	.45	19.37			2.54	5.65
		51	.458	23.37			3.06	6.70

Note: Very poor and insufficient labor on all paving.

SUMMARY OF THE COST OF TRENCH EXCAVATION

Trench	Total Hours	Av.Rate/ Hour.	Total Cost	No. Hrs.	Unit	Cost per Unit	Hours per Unit
1-2	579	.477	276.35	80.03	Cu.Yd.	3.45	7.22
4-5	489	.494	241.85	102.00	"	2.36	4.78
5-6	426	.495	210.93	125.00	"	1.68	3.40
6-7	293.5	.495	145.40	74.50	"	1.94	3.92
7-8	276	.488	134.78	81.40	"	1.64	3.37
9-10	683	.469	310.75	100.30	"	3.20	6.79
Total	2746.5	.484	1330.06	563.25		2.38	4.88
		HAULING EXCAVATION.					
Total 7 trenches.	501.5		462.45	403.2	"	1.15	1.24
		BACKFILLING TRENCHES.					
0-1	114	.45	51.30	104.8	"	.49	1.09
5-6	81.5	.451	36.80	66.7	"	.55	1.22
7-8	68.0	.457	31.10	40.6	"	.77	1.69
Total	263.5		119.20	212.1	"		
Average		.452			"	.564	1.24
		Mixing & Laying Concrete In Trenches					
1-2	451	.469	211.65	30.5	Cu.Yd.	6.93	14.78
4-5	242.5	.470	114.15	38.06	"	2.98	6.36
5-6	374	.470	175.75	38.0	"	4.61	9.83
6-7	217	.474	103.05	32.3	"	3.18	6.71
7-8	186.5	.474	88.55	30.9	"	2.86	6.03
8-9	220	.498	109.50	38.82	"	2.80	5.65
9-10	261	.475	123.95	38.2	"	3.23	5.52
Total	1952		926.60	246.78	"		
Average		.475			"	3.75	7.91
		LAYING 4 INCH DUCT.					
Total 10 trenches	554	.54-5/8	302.04	25.299	MFt.	11.94	21.90
		LAYING BRICK PAVING.					
1-2	100	.45	45.00	60.0	Sq.Yd.	.75	1.66
4-5	151	.464	70.05	76.7	"	.914	1.98
5-6	210	.464	97.45	74.1	"	1.307	2.83
6-7	206	.456	93.95	63.3	"	1.47	3.26
Total	667		306.45	274.1	"		
Average		.460			"	1.118	2.43

SUMMARY OF MANHOLE COSTS.

EXCAVATING MANHOLES.

Man-hole	Total Hours	Ave.Rate/ Hour.	Total Cost	Quantity	Unit	Cost per Unit	Hours per Unit
#1	120	.525	63.00	25.8	Cu.Yd.	2.43	4.64
#2	118	.545	64.30	25.9	"	2.46	4.54
#3	182.5	.505	91.35	28.9	"	3.15	6.30
#4	171.5	.558	85.68	23.5	"	3.64	7.29
#5	108	.564	60.95	25.9	"	2.35	4.15
#6	89	.503	44.75	21.8	"	2.04	4.08
#7	131	.492	64.45	22.6	"	2.85	5.79
#8	89	.505	44.95	21.7	"	2.06	4.09
#9	61	.553	33.75	20.0	"	1.69	3.05
Total	1067000	.	553.18	216.1	"		
Average		.5170				2.560	4.951

Hauling Excavation

Total	192		174.60	196.1			
Average						.89	.98

Erecting Manhole Forms.

#1	40	.703	29.20	246.6	Sq.Ft.	.11	.16
#2	53	.704	37.50	208.8	"	.18	.24
#3	28.5	.80	22.80	254.7	"	.09	.11
#4	59	.723	42.65	234.9	"	.18	.25
#5	38	.80	30.40	220.5	"	.14	.17
#6	51	.80	37.40	207.9	"	.18	.25
#7	31	.80	23.50	224.1	"	.11	.14
#8	34	.80	27.20	209.7	"	.13	.16
#9	40	.80	32.00	199.35	"	.16	.20
Total	374.5	.	282.65	2006.55	"		
Average		.7547				.141	.186

Mixing And Pouring Concrete.

#1	78	.513	40.00	7.98	Cu.Yd.	5.02	9.77
#2	98.5	.458	45.08	8.13	"	5.55	12.12
#3	52	.4555	23.65	11.27	"	2.09	4.61
#4	86	.465	40.05	9.30	"	4.31	9.25
#5	85	.459	39.00	11.37	"	3.43	7.47
#6	62	.467	28.95	9.00	"	3.22	6.89
#7	76	.514	39.10	9.26	"	4.22	8.20
#8	63	.474	29.85	8.70	"	3.43	7.24
Total	600.5		285.68	75.01	"		
Average		.4757			"	3.806	8.006

SUMMARY OF MANHOLE COSTS (CONTD).

Wrecking Forms in Manholes.

Manhole	Total Hours.	Ave.Rate/ Hour.	Total Cost	Quantity	Unit	Cost per Unit	Hours per Unit
#1	13	.773	10.05	246.6	Sq.Ft.	.040	.051
#2	14	.65	9.10	208.8	"	.043	.068
#3	14	.775	10.85	254.7	"	.043	.064
#4	2	.80	1.60	234.9	"	.007	.008
#5	19	.774	14.15	220.5	"	.064	.086
#6	4	.80	3.20	207.9	"	.015	.015
#7	4	.80	3.20	224.1	"	.014	.017
#8	8	.525	4.20	209.7	"	.019	.038
#9	7	.80	5.60	119.35	"	.028	.055
Total	85	.	61.95	2006.55	"		
Average		.7276				.0309	.0424

PLACING STEEL IN MANHOLE TOPS.

Total 7 Manholes.	51.5 (Average)	.494	25.43	40.58	Cwt.	.626	1.047

LAYING BRICK PAVING.

#1	34	.463	15.75	9.11	Sq.Yds.	1.76	3.73
#2	37	.463	17.15	9.50	"	1.81	3.85
#3	40	.469	18.75	10.20	"	1.84	3.92
#4	22	.468	10.30	7.96	"	1.29	2.76
#5	8	.475	3.80	9.16	"	.41	.88
#6	29	.471	13.65	7.61	"	1.79	3.81
#7	40	.466	18.65	7.61	"	2.45	5.26
#8	22	.461	10.15	7.61	"	1.33	2.89
#9	51	.458	23.37	7.61	"	3.06	6.70
Total	283		131.57	76.37	"		
Average		.4649			"	1.723	3.706

SUMMARY OF CONTRACT LABOR COSTS & TIME.

Item	Total Hours	Av.Rate per Hour	Cost
Common Labor:-(Includes Carpenters @$.80 Sewermen @ .60 Laborers @ .50 Laborers @ .45)	12149	$.4914	$7306.02
Teams:- (Used on disposal of excavation only)	994	.9392	898.50
Common Labor plus Teams	13143	.6242	$ 8204.52
Superintendence & General Labor			
Superintendent. Av.2 Hrs/ day on job	112	1.0500	184.80
Foremen (3 Regular;2 extra for short time)	1716	.8107	1391.10
Timekeeper - 1	222	.7000	155.40
Watchman - 1	530	.4000	212.00
Toolman -1	530	.4250	225.25
Engineer - 1 (Ran engine for concrete mixer and pumping.	335	.75000	251.25
Total superintendence & General Labor.	3445	.7034	$ 2419.80
Workmens Compensation Ins, 1.77%			186.05
Contractors Tool Expense:			452.35
Contractors Profit on Labor & Tools 8 %			1055.59
GRAND TOTAL	16588	$ .7367	$ 12320.31

The preceeding analysis of the data gives the average cost in dollars per unit and in hours per unit.

Due to the time of year in which the work was undertaken some of the figures are not consistent. These have been omitted from the summary. For example the item of excavation for trench 9-10 is $ 3.15 per cubic yard and 6.75 hours per cubic yard; this trench was excavated while the ground was frozen. Comparing it with trench 6-7 which contained water but was excavated for $ 1.78 per cubic yard and 3.72 hours per cubic yard, also trench 5-6 which was excavated under favorable conditions at $ 1.52 per cubic yard and 3.2 hours per cubic yard, would make the excavation of trench 9-10 classify as solid rock excavation under the conditions obtaining, and the cost indicates some such classification.

Reference has been made to the lax cooperation between members of the contractors organization earlier in the analysis. The costs as given are high but are fair in value when the method of doing the work is considered. One of the objections to the so called "Cost Plus" method of contracting work is the tendency of the contractor to pay but little attention to the efficiency of his labor crew. In fact a large labor turn-over is a source of revenue for the Contractor when operating on the "Cost Plus" or "Force Account" basis.

The term "Dollars per unit" does not give any indication of the number of hours required to complete or make a unit. When a proposal is made it is given in lineal or mass units, not in so many "Dollars of work".

The amount of work a man can do under usual practical conditions is fairly constant, but such is not the condition of the renumeration which he receives. Therefore an application of "Hours per unit" will give truer values than "Dollars per unit".

For an example I shall make an estimate on a proposed job using the unit of "Hours per unit" and show the necessary computations.

The school contemplates the construction of a concrete tunnel to carry high and low pressure steam mains to Swann dormitory and itermediate buildings between the dormitory and the power plant. The tunnel to have the following approximate dimensions and quantities:

Length ..... 820 ft. Thickness of tunnel walls 4 ins.
Width ..... 4 ft. Thickness of tunnel top 6 ins.
Depth ..... 5 ft. Thickness of tunnel bottom 0 ins.

See incolsed sketch for other general dimensions.

Common excavation 820 x 4 x 5 ÷ 27 ..... 607.5 cu.yds.
Weight of steel 820 x 4 x 0.668 ÷ 2 ..... 1096 lbs.
Concrete:
top 820 x ½ x 4 ÷ 27 ..... 60.7 Cu.yds.
walls 2 x 820 x 3 ÷*3 x 27 ..... 60.8 cu.yds.
Backfill 607.5 -(820 x 4 x 3.5 ÷ 27) ..... 182.5 cu.yds.
Forming lumber 14 x 820 ..... 11480 Sq.ft.

MATERIAL:

180 ft. 8 in. Std. b pipe @ 3.50 less 1/3	300.60
640 ft. 6 in. " " " @ 1.90 " 1/3	812.80
4 Expansion joints	1200.00
13 Bbls. Cement @ 3.20	41.60
40 Cu.yds. Sand @ 1.65	66.00
131 Tons Stone @ 3.00	393.00
2 M Ft. 1"x6" x 8'-10'-12' @ 27.00	54.00
0.2 M Ft. 2"x 4" x 12'-16' @$30.00.....	6.00
1100 Lbs, Steel ½" reinforcing rod @ 0.04	44.00
	$ 2918.00

Crew:

30 laborers @ 30¢	9.00
2 Carpenters @ 70¢	1.40
1 Foreman @ 90¢	.90
1 Waterboy @ 35¢	.35
34	11.65

Average or Base rate 11.65 ÷ 34 = 0.343 ¢ per hour.

TOTAL TIME:

Excavating 607.5 Cu.yds. @ 4.88 hrs/cu.yd	2964.6 hrs.
Hauling excavation, 435 cu.yds @ 0.98 hr/cu.yd.	416.5 "
Backfilling 182.5 Cu.yds. @ 1.24 hr./Cu.yd.	226.3 "
Concrete work 122 Cu.yds. @ 7.91 hr./cu.yd.	965.0 "
Form Work 2M ft. @ 0.186 hr./cu.yd.	362.0 "
Placing steel 1100 lb. @ 1.047 hr./cwt.	11.7 "
	4946.1 "

LABOR COST:

4946.1 hrs. @ 0.343¢/hr.	1696.51
112 hrs. pipe fitter @ 1.12½	126.00
112 hrs. pipe fitter helper @ 50¢	56.00
	1878.51
Superintendence 2 %	
Workmens Compensation Insurance 1.7 %	
3.7 % of 1878.51	69.50
Total labor	1948.01
Total material	2918.00
Grand total ..... $	4866.01

If this work is let on competitive bidding an allowance of 30% should be made for tools, machinery and contractors profit, thereby making the total cost of the finished job at present prices $ 6325.80.

POWER PLANT

MH

20 Ft.

160 Ft.

CRYSTAL PALACE

MACHINE SHOP

WALK.

DRIVE-WAY.

ELECTRICAL BUILDING

SWANN DORMITORY

HOSPITAL.

REHAB CLASS ROOM.

1 2 3 4

540 Ft.

C H E R R Y S T.

100 Ft.

MECHANICAL BUILDING

½ IN. Steel Spaced 6ins C to C.

6"

36"

42"

4" 40" 4"

48"

ELEVATION OF TRENCH.

NOTE: Inside Forms For Walls And Top Manholes to be finished One Foot Above Grade. Nos. 2, 3 and 4 Have A 4x4 foot Opening: No1. 4x6 Ft.

GRADE

TOP OF PIPE TUNNEL

2 Ft.

80 Ft.

TOP OF TRENCH 1 Ft. BELOW GRADE.

SKETCH OF HIGH AND LOW PRESSURE PIPE LINE LAYOUT FOR THE GA. SCHOOL OF TECH. AT LANTA GA.

FEB 23 1926 W.L.M.C.

POWER PLANT

20 ft.

160 ft.

CRYSTAL PALACE

MACHINE SHOP

HOSPITAL

REHAB CLASS ROOM.

WALK.

DRIVE-WAY.

ELECTRICAL BUILDING

SWANN DORMITORY

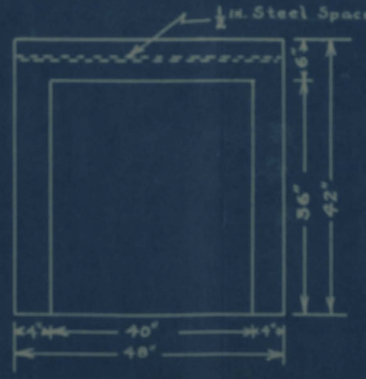
1 2 3 4

100 ft.

540 ft.

C H E R R Y S T .

MECHANICAL BUILDING



ELEVATION OF TRENCH.

NOTE: Inside Forms For Walls And Top Manholes To Be Finished One Foot Above Grade. Nos. 2, 3 and 4 Have A 4x4 Foot Opening: No. 1 4x6 ft.

GRADE

TOP OF PIPE TUNNEL

80 ft.

TOP OF TRENCH 12' BELOW GRADE.

SKETCH OF HIGH AND LOW PRESSURE PIPE LINE LAYOUT FOR THE GA. SCHOOL OF TECH. ATLANTA GA.

DATE 1924 WILEY

CROSS SECTION OF BUCY LINE LEAVING MANHOLE 3

CROSS SECTION OF BUCY LINE ENTERING MANHOLE 10.

2175'

CHERRY

LYNN

JACKSON

ADAMS

MADISON

UNDERGROUND CONDUIT
CONSTRUCTION ON WATER ST.
BETWEEN MADISON AND LOCUST
ENG. DEPT SEPT. 11, 1911.
CO. No. X 1445. SCALE 1"=100'